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June 17, 1992

Mr. Jim Williams
Department of the Air Force
Center for Environmental Excellence (AFCEE)
Environmental Restoration Division (ESR)
Building 624 West
Brooks AFB, Texas 78235-5000

Subject: F33615-90-4014, Order 04, Mod. 04
Bioventing System Start-Up Report

Dear Mr. Williams:

This letter presents the start-up report for the bioventing system at the 7th Street BX Service Station. Copies are being distributed as you requested. This letter report is organized as follows:

- Introduction
- Bioventing System Start-Up and Optimization
 - Pre-Venting Conditions (oxygen/carbon dioxide levels)
 - Respiration Test
 - System Start-Up
 - System Optimization
- Future Monitoring Schedule

Sincerely,

ENGINEERING-SCIENCE, INC.

Ola A. Awosika, P.G.
Project Manager

OAA:al
Attachment

cc/att: Patricia Williamson
Major Miller (c/o Jim Williams)

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INTRODUCTION

Between May 11 and 15, 1991, ES installed a bioventing system at the 7th Street BX Service Station. The 7th Street BX Service Station is located near the intersection of 7th Street and Eglin Boulevard on Eglin Main Base (Figure 1). Site description and history were presented in the Engineering Work Plan for installation of this system (ES, 1992). Previous and ongoing investigations at the site revealed presence of volatile and semivolatile organic compounds in the groundwater. Contaminants detected are mostly constituents of gasoline. Free product has been measured at the site at various times over the past 5 years. No soil sampling or analysis has been completed previously at the site. However, a significant portion of the soil at the site is suspected to be impacted by the release of gasoline into the subsurface. Currently, a groundwater recovery and treatment system is being operated at the site to remove floating and dissolved petroleum hydrocarbons from the groundwater. The groundwater recovery and treatment system is incapable of remediating soil contamination, therefore, the bioventing treatability system is intended to remediate the soil contamination.

The objective of the bioventing system at the 7th Street BX Service Station is to aid in expediting remediation efforts at the site. This objective was developed through evaluation of previous investigation results, current remediation efforts, and results of a bioventing pilot test at the site.

Prior to installing the system, a Sampling and Analysis Plan and an Engineering Work Plan were prepared. Upon satisfactory review of these plans, ES was directed by Mr. Jim Williams (AFCEE) to proceed with installation of the system. ES employed the services of four subcontractors during the construction and installation of the bioventing system: Griner Drilling Services, Inc.; Choctaw Engineering Services; Southwest Laboratories; and Bearden Construction, Inc. Griner Drilling Services, Mobile, Alabama provided drilling and excavation services including installation of wells and piping for the system. Choctaw Engineering Services, Ft. Walton Beach, Florida provided surveying services. Bearden Construction Inc., Ft. Walton Beach, Florida provided electrical services. Southwest Laboratories of Oklahoma provided analytical laboratory services for sample analyses.

The bioventing system consists of two vapor extraction wells (VEWs), two vapor monitoring points (VMPs), and two vacuum recirculation and injection trenches (Figure 2). The boring logs for the VEWs and VMPs are included in Attachment A. Soil samples were collected from the boring for these wells for analyses of TPH and BTEX compounds. Results of these analyses are pending. The as-built flow schematic for the system and other construction information and specifications are included in Figure 3.

Following completion of the construction and installation work, ES began preparation for start-up of the system. The following information provides the details of the preparation effort, the start-up and optimization efforts.

BIOVENTING SYSTEM START-UP AND OPTIMIZATION

Pre-Venting Conditions (Oxygen/Carbon Dioxide Levels)

Prior to initiating venting at the site, initial soil gas concentrations of oxygen and carbon dioxide were measured at the two new vapor monitoring points (VMP-1, VMP-2), two existing ground water monitoring wells (MW-1, MW-10), and a background soil gas probe located approximately 500 feet north of the site. The depth of the background soil gas probe was 3 feet and the probe was driven at the edge of a large asphalt area. Soil gas conditions in all monitoring points within the fuel spill area were oxygen depleted with all points reading 0.0 percent oxygen. Carbon dioxide in all points within the spill area exceeded 15 percent. These (anaerobic) soil gas conditions indicate that fuel biodegradation is oxygen limited and will benefit from oxygen addition. In contrast, oxygen and carbon dioxide concentrations in the background soil gas monitoring probe were near atmospheric conditions at 20.4 percent and 0.6 percent respectively. The oxygen and carbon dioxide levels found in background soils indicate that the oxygen deficient vapor found at the 7th street site was not caused by natural carbon biodegradation or abiotic (chemical) oxygen uptake in the soil but are the result of increased biologic activity.

Respiration Test

An in-situ respiration test was conducted to confirm the presence of biological activity and to determine the initial oxygen utilization rates for this fuel spill site. The test began by injecting air into VMP-1 (Deep) and VMP-2 (Shallow) for approximately 12 hours to build up the supply of oxygen in the soil. Prior to air injection, soil oxygen concentration of zero was measured in both VMP-1 and VMP-2 indicating a severe oxygen limitation. Following the 12 hours of air injection, soil oxygen levels were increased to over 20 percent in both VMPs. Table 1 and Figure 4 illustrate the results of the oxygen utilization test. Rates of oxygen utilization varied from 0.15 to 0.28 percent oxygen per hour which closely compare to a oxygen utilization ratio of 0.12 to 0.36 percent oxygen per hour measured in similar soil and climatic conditions at Tyndall AFB, Florida. (Miller, 1990).

The rate of fuel biodegradation at the 7th Street Service Station site can be estimated using the equation:

$$K_B = K_o A D_o C / 100$$

Where:

$$K_B = \text{fuel biodegradation rate (mg/kg day)}$$

K_o = oxygen utilization rate (percent per day) (3.6 to 6.7)

A = volume of air/kg of soil (l/kg) (estimate .21 l/kg soil)

D_o = density of oxygen (mg/l) (1330 mg/l)

C = mass ratio of hydrocarbon to oxygen for mineralization (1:3.5)

Solving:

K_B = 2.9 to 5.3 mg/kg/day or from 1000 to 2000 mg/kg/yr

ES believes these rates will increase over the first few months of bioventing as the aerobic bacterial population is reestablished in the oxygen enriched environment. A repeat respiration test, scheduled for late August 1992, will determine the oxygen enriched, long term respiration rates at the site.

System Start-Up

At 0800 on 20 May 1992, bioventing was initiated at the 7th Street Service Station. During the initial 30 minutes of venting the dilution valve was completely closed and the oxygen concentration vs. time at key monitoring points was measured. The vacuum response and flow of soil gas toward each venting well was both rapid and uniform. Equilibrium was reached in approximately 10 minutes. In order to determine if the flow rate from VEW-1 and VEW-2 was approximately the same, the steady state vacuum response of VMP-1 and VMP-2 were compared. Since these VMPs are approximately the same distance from their respective VEWs, a comparison of vacuum response provides an estimate of the flow through each VEW. The shallow vacuum response in VMP-1 and VMP-2 was identical after 10 minutes of venting. The deep vacuum response at VMP-2 was slightly greater than VMP-1 indicating a slightly higher flow gradient in VMP-2. Due to the similar vacuum influence and flow rates of the VEWs, both flow valves were left wide open throughout the remainder of this test.

Vacuum levels at the filter inlet, filter outlet, and blower outlet were also monitored to determine blower performance and flow rate. With the dilution valve closed, vacuum at the air filter inlet was 28" H₂O, head loss through the filter was 18" H₂O, and pressure at the blower exit was +18" H₂O. The total pressure across the blower of 64" H₂O was slightly greater than the manufacturer's recommended operating maximum of 60" H₂O. Based on the manufacturer's blower curve, approximately 35 scfm of soil gas was being removed from the venting wells at a vacuum pressure of 64" H₂O.

After approximately 90 minutes of operating, the oxygen, carbon dioxide and volatile hydrocarbon concentrations were measured in the sampling port located upstream of the dilution valve. An oxygen concentration of 4.5% was measured in the vented soil gas into the contaminated area. Carbon dioxide was reduced from an average pre-venting concentration of >15% to 12%. Initial volatile hydrocarbon concentrations were difficult to measure because of high initial levels. A 1:12

dilution was required to bring the concentrations to within the TraceTechor gas analyzers calibration range of 0 to 10,000 ppmv. Using this dilution, an initial concentration of approximately 90,000 ppmv (as hexane) was measured.

System Optimization

The bioventing system at this site was designed to provide both oxygen to the primary spill area beneath the asphalt and to reinject hydrocarbon vapors into a "biofiltering" trench where biodegradation of vapors will take place. System optimization requires reducing the soil gas extraction rate in the highly contaminated area, while maintaining enough oxygen influx to sustain initial fuel biodegradation rates. The optimization was accomplished by opening the dilution valve in steps and then measuring vacuum response and oxygen influx at vapor monitoring points and the extracted soil gas. An additional goal of the initial optimization was to insure that adequate oxygen was provided to the "biofilter" trench to biodegrade injected vapors. This objective was also accomplished by adjusting the dilution valve to supply oxygen rich ambient air to the trench

Table 2 illustrates the change in vacuum and soil gas concentrations resulting from each optimization step.

At 0900 on 21 May the dilution valve was set at the final 1:3 dilution and the dilution valve handle was removed. Final vacuum response readings were taken to insure that soil gas movement (oxygen influx) was occurring at this lower dilution rate. All monitoring points registered vacuum levels of 0.2" H₂O or higher. Final soil gas oxygen concentration ranged from 12.0 to 20.8 percent throughout the contaminated soil volume indicating that a combined flow of 15 cfm through VEW-1 and VEW-2 will be sufficient to oxygenate contaminated soils beneath the asphalt and soils at 15 to 20 feet on each side of the air injection trenches. Based on an estimated contaminated soil volume of 26,000 cubic feet, the soil gas extraction rate of 15 scfm represents approximately one pore volume exchange per day. Previous bioventing studies have shown that in-situ biodegradation can be sustained at this level of oxygen influx (Miller).

FUTURE MONITORING

ES will make biweekly system checks, change air filters and record all operating vacuums, pressures, and temperatures in and out of the blower system. During the initial three months of operation, two samples of extracted soil gas will be collected each month by ES personnel and analyzed for volatile hydrocarbons, oxygen and carbon dioxide. One sample will be collected from the sample port located upstream of the dilution valve, the second gas sample will be collected from the pressure discharge of the blower. Samples will be collected in Tedlar bags, labelled as "before dilution" and "after dilution" and shipped to ES Denver for analysis with a Gastech TraceTechor hydrocarbon analyzer and GasTech O₂/CO₂ analyzer.

Once each quarter, an ES technician will complete an in-situ respiration test in VMP-1 and VMP-2 to measure the rates of oxygen utilization and fuel biodegradation. Soil gas samples will also be analyzed from MW-1 and MW-10 to determine the steady state oxygen levels within the contaminated soils. Table 3 provides a summary of the recommended monitoring schedule for the 7th Street Service Station bioventing site.

TABLE 1

**OXYGEN UTILIZATION DURING IN-SITU RESPIRATION TEST
(IN PERCENT OXYGEN)
7TH STREET BX SERVICE STATION
EGLIN AFB**

Vapor Monitoring Point	Hours							
	0	3	7.5	11.5	17	24		
VMP-1 (Shallow)	20.9	20.1	17.6	16.9	16	13.9		
VMP-1 (Deep)	20.9	20.1	18.8	17.5	16	14.9		
VMP-2 (Shallow)	20.9	19.5	18.1	17	16.4	15.5		
VMP-2 (Deep)	20.9	20.2	19.1	18.4	18	17.1		

TABLE 2
VACUUM RESPONSE AND HYDROCARBON CONCENTRATIONS
DURING SYSTEM OPTIMIZATION
7TH STREET BX SERVICE STATION
EGLIN, AFB

Dilution Factor	No Dilution	1:1	1:3
Vacuum in Vent Line ("H ₂ O)	24	10	5
Total Extraction Flow Rate (scfm) ⁽¹⁾	35	50	60
Vacuum in MW-10 ("H ₂ O)	2.5	1.0	0.5
Hydrocarbons into Biofilter (% by volume)	9	4.6	2.4
Oxygen into Biofilter (% by volume)	4.5	20.5	20.6
Estimated Flow Under Asphalt (scfm)	35	25	15

(1) Estimated from manufacturer's blower curves.

TABLE 3
MONITORING RECOMMENDATION FOR THE
7TH STREET BX SERVICE STATION
EGLIN AFB

Sampling Location	Analysis/Measurements	Frequency
Before Dilution Valve	Hydrocarbons, O ₂ , CO ₂ , Vacuum Pressures	Monthly
Downstream of Blower	Hydrocarbons, O ₂ , CO ₂ , Vacuum Pressures	Monthly
VMP-1 Shallow and Deep	Respiration Test, Initial O ₂ , CO ₂	Quarterly
VMP-2 Shallow and Deep	Respiration Test, Initial O ₂ , CO ₂	Quarterly
MW-1	Respiration Test, O ₂ , CO ₂	Quarterly
MW-10	O ₂ , CO ₂	Quarterly

EGLIN AFB
LOCATION OF 7th STREET BX SERVICE STATION

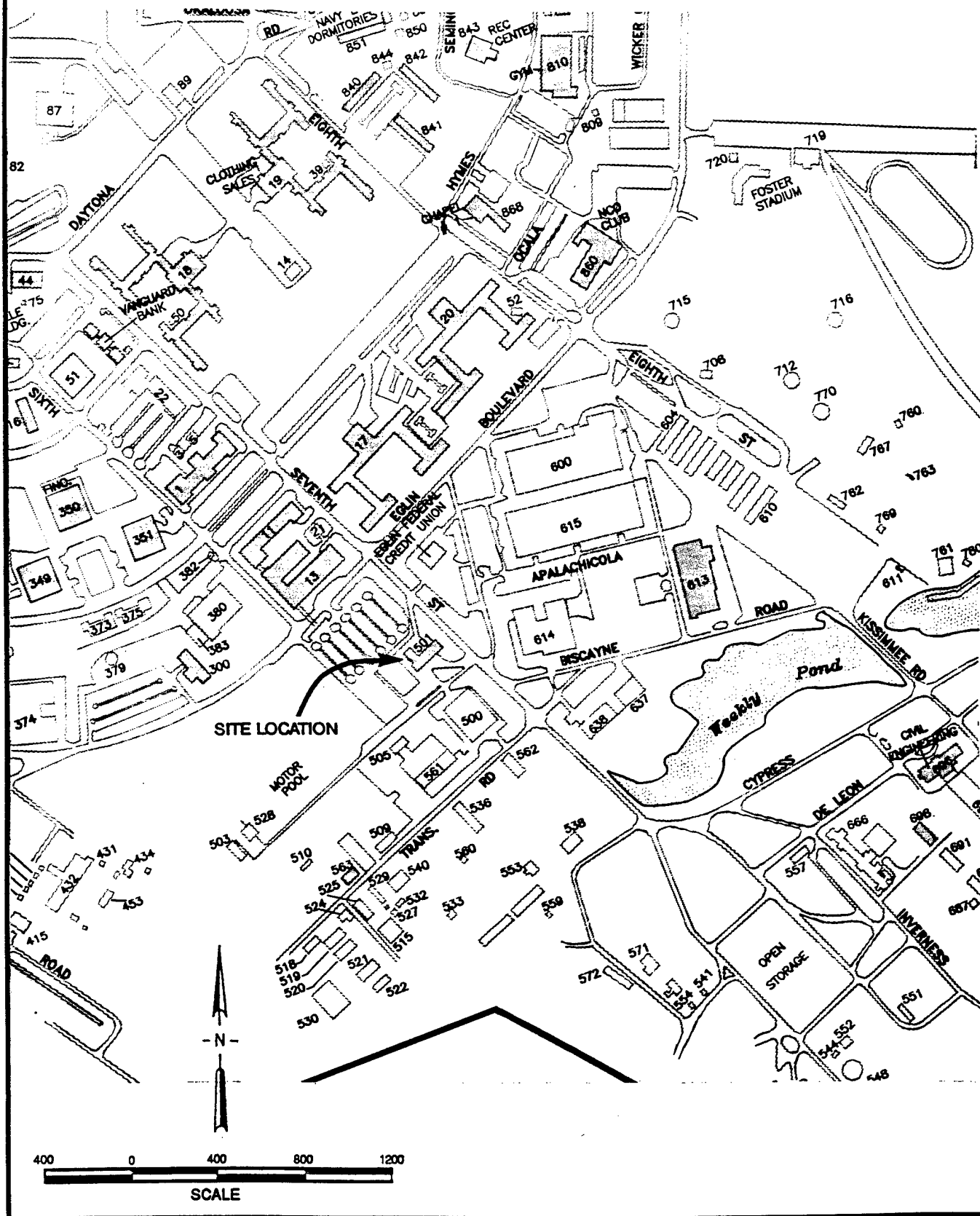
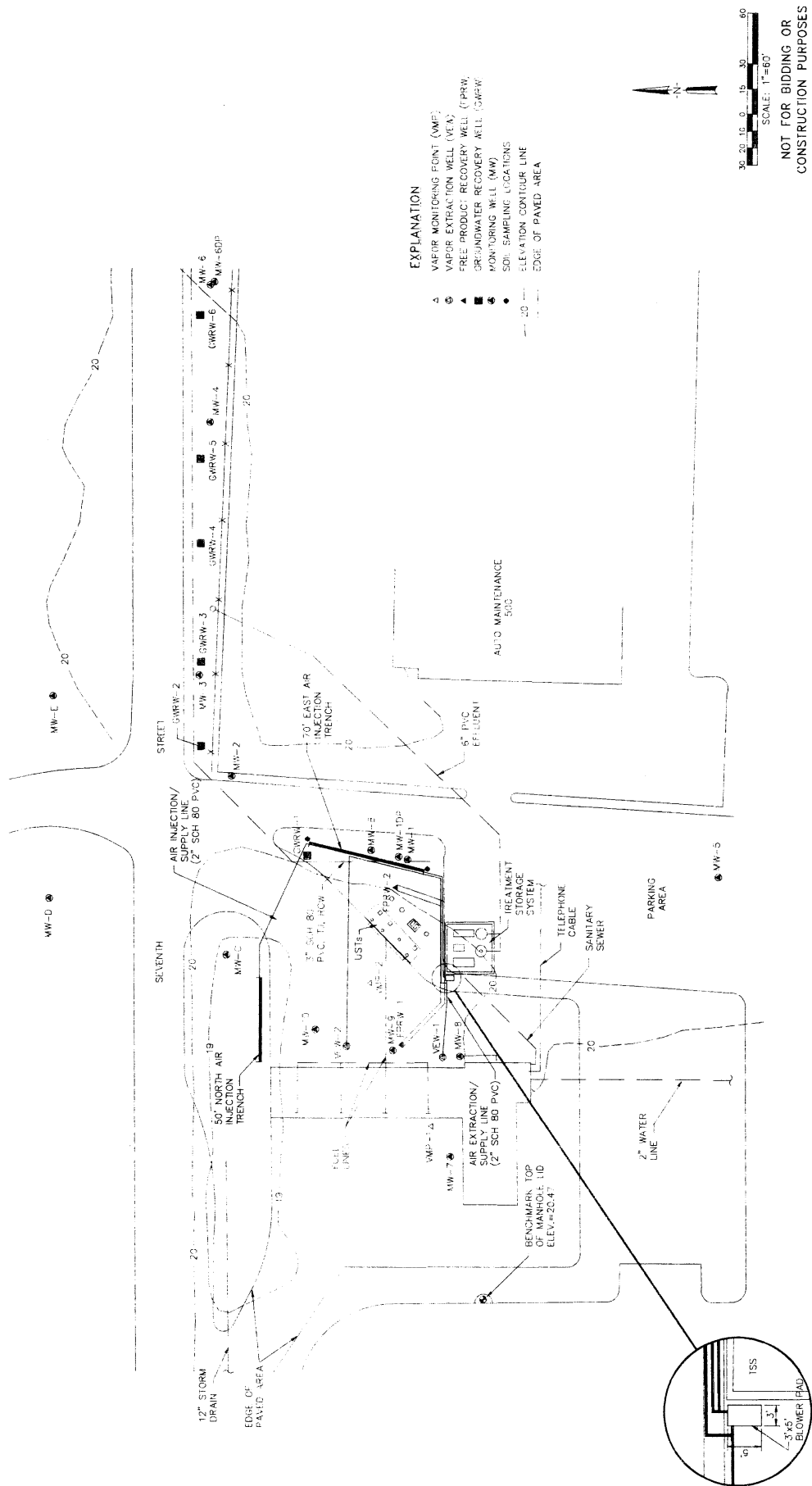
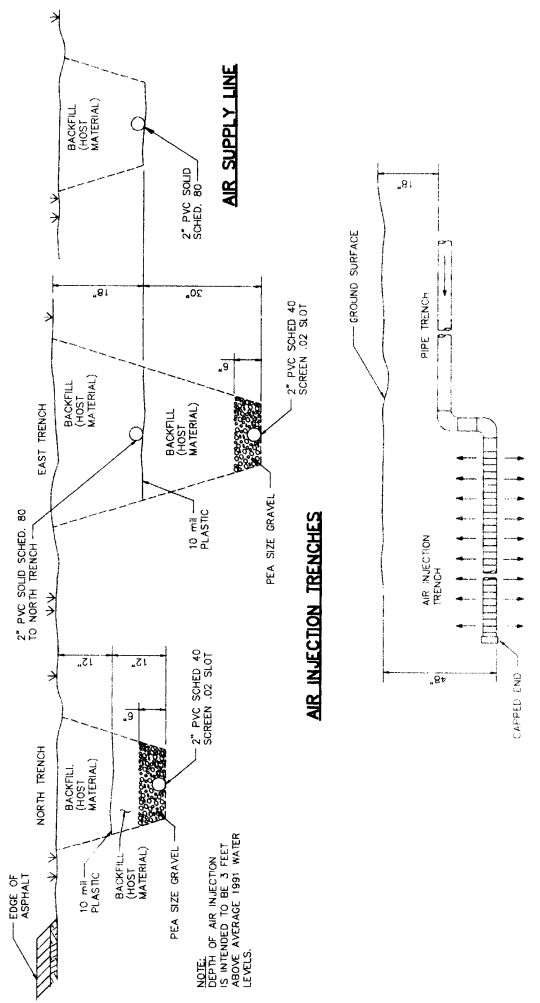


Figure 2



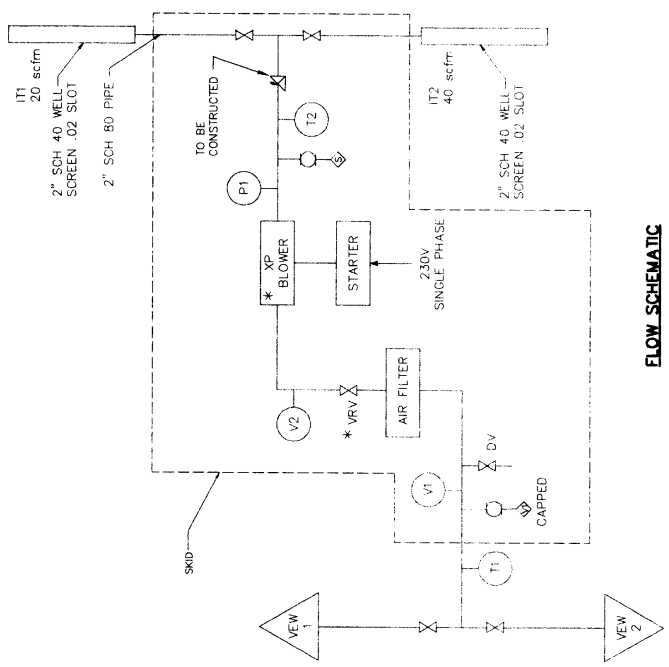
NO. DATE		REVISIONS	PROJECT NO.	1510	<div> <p>ENGINEERING SCIENCE DESIGN • RESEARCH • PLANNING 1100 N. W. 10th Street, Suite 200, Ft. Lauderdale, FL 33304 Tel: 754/561-1234 Fax: 754/561-1235</p> </div>	<div> <p>EGLIN AFB</p> <p>7th STREET BX SERVICE STATION</p> <p>FLORIDA</p> </div>	<div> <p>BIOVENTING SYSTEM</p> <p>INSTALLATION PLAN</p> </div>	<div> <p>SCALE: 1" = 60'</p> <p>SHEET NO.</p> <p>FIG. NO.</p> <p>SITING DRG</p> </div>
1	5/9/92	REVISION						
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Figure 3

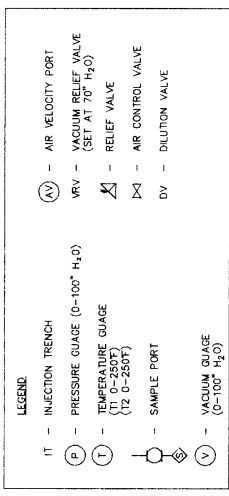


TYPICAL SECTION

TYPICAL SECTION OF AIR INJECTION TRENCHES AND PIPE TRENCH

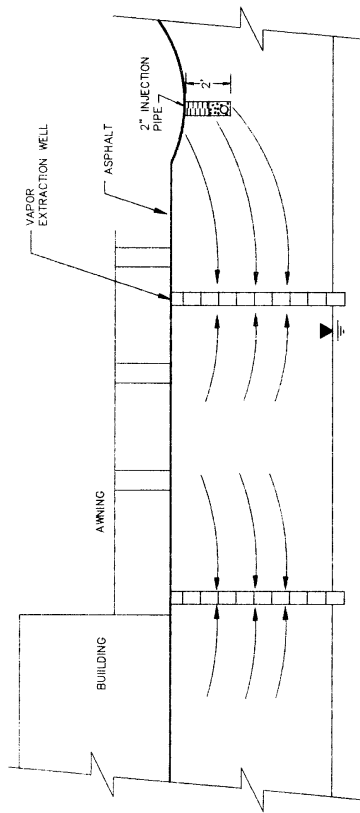


FLOW SCHEMATIC



* BLOWER SPECS: CAST RS125-1 (2.5 HP) OR EGAG ROTATION MODEL (2.5 HP) 230V, 115/230V, EXPLOSION PROOF, 2 HP SINGLE PHASE 115/230V, MAX AMPS = 11.5A AT 230V, VACUUM RELIEF VALVE SPECS: CAST AQ256 1 1/2" NPT, ADJUSTABLE 30" - 170" H₂O, 200 cfm MAX, SILENCER FOR RELIEF VALVE, AUTZID

FLOW SCHEMATIC FOR THE BIOVENTING SYSTEM



CONCEPTUAL CROSS-SECTION DESIGN FOR IN-SITU RECIRCULATION

NOTE:
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ENGINEERING—SCIENCE DESIGN RESEARCH PLANNING 10000 N. W. 11th Ave., Suite 200, Fort Lauderdale, FL 33322-4000	ES	EGLIN AFB 7th STREET BX SERVICE STATION Florida	CONCEPTUAL DETAILS — MISCELLANEOUS	SCALE SHEET NO. 4 FILE NO.
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RESULTS OF THE OXYGEN UTILIZATION TEST
7TH STREET GASOLINE STATION
EGLIN AFB

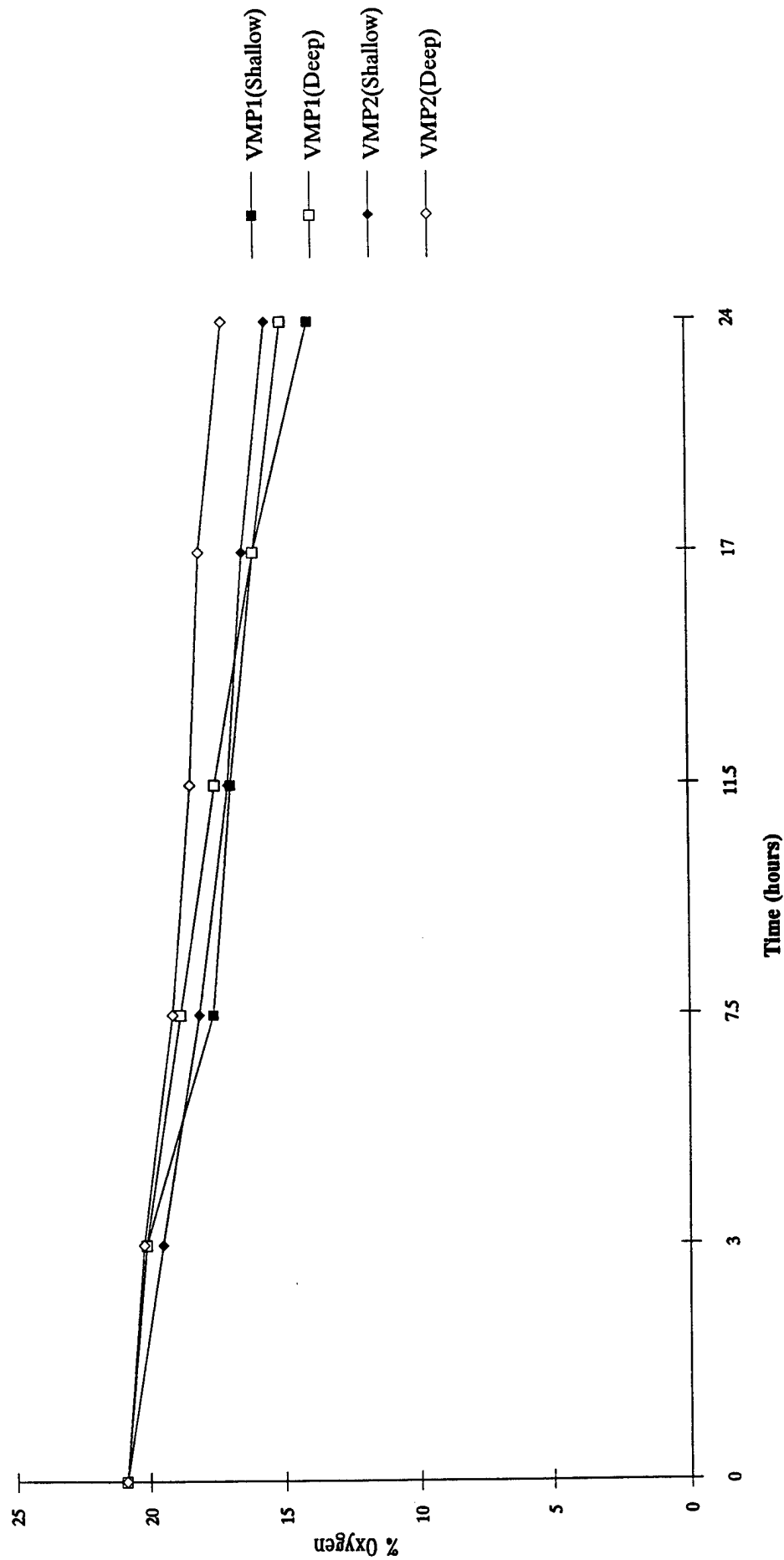


Figure 4